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TWO SOURCE UNITS IN A COURSE OF GENERAL COLLEGE CHEMISTRY

Submitted by

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the degree of Master of Education

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CHAPTER I

THE SCOPE AND PURPOSE OF THIS PAPER

The Problem.-- The traditional college chemistry course is essentially a lecture course. This method of teaching disregards individual differences, tends to develop an attitude of passive receptivity, and neglects the educational need wherein the student becomes self-educated. This paper is an attempt to apply the basic principles and procedures set forth by Dr. Roy O. Billet in his book 1/ and the course entitled "The Unit Method" which is taught at Boston University, to the construction of two source units of a course in general college chemistry.

The original intention was to teach and evaluate these two units during the summer or fall term of 1948 at the University of Massachusetts at Fort Devens, Massachusetts, but the course which contains the two units will not be offered in the summer term and the writer may be recalled to active duty in the fall or will not be teaching on a college level. As a result, the units were converted to source units. If the units are taught in the future, they will be evaluated and that evaluation submitted as an addition to this paper.

An examination of the table of contents of twelve recent textbooks

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1/ Roy O. Billett, Fundamentals of Secondary School Teaching, Houghton Mifflin Co., Boston, Mass., 1940.

on general college chemistry 1/, reveals that the following topics appear most frequently in the first half of the text: Matter and Energy, Changes in Matter, Atoms, Molecules, Ions, Atomic and Molecular Weights, Symbolism of Chemistry, Oxygen, Hydrogen, Valence, Properties of Gases, The Gas Laws, Kinetic-Molecular Theory, Oxides and Their Reactions, Solids, Liquids, Chlorine, Hydrochloric Acid, Solutions, Determination of Atomic and Molecular Weights, Problems Based on Equations, The Halogens, The Periodic Table, Atomic Structure, Radioactivity, Ionization of Acids, Bases and Salts, and The Atmosphere.

Although most of the authors agree as to what should be taught during the first semester, they disagree widely on the sequence of topics. Many of these topics are closely related and can be studied in groups or units for maximum correlation, integration, and transfer of learning. It should be noted that the topics Atomic Structure, Radioactivity, and The Periodic Table appear at the end of the list. In this paper, they will appear earlier for the reason that the student needs a knowledge of the atoms and the elements as an insight for later units in the understanding of their physical make-up and relationships which enables them to react as they do. 2/

The local situation.-- The units were developed so as to be

1/ The textbooks examined by the writer include all the texts of the selected bibliography of the unit assignment of Chapter III, and Joel H. Hildebrand, Principles of Chemistry, The Macmillan Co., N. Y., 1947.

2/ Textbooks number two and nine in the selected bibliography of the unit assignment of Chapter III, and Hildebrand, op. cit.

taught at The University of Massachusetts at Fort Devens, Massachusetts, whose doors were opened on October 1, 1946 to the Massachusetts veterans of World War II. The campus occupies that portion of Fort Devens which contains the permanent buildings, parade ground, commissioned and non-commissioned officers quarters and the separation center.

This institution was conceived as a result of the overcrowded condition of all colleges and universities throughout New England; and the purpose of this institution is to provide the first two years of college training to students who are seeking admittance to the parent institution, The University of Massachusetts at Amherst, or elsewhere.

The students are a heterogeneous group with a wide variance of social and economic background as well as representing many religions, nationalities, and races. They are admitted upon presentation of a high school diploma and a transcript of records showing college certification grades. 1/ If the prospective student cannot show college certification grades, he can then be admitted if he passes the College Board Examinations, The Basic Cooperative Comprehensive Test in English and in Algebra, and The American Council on Education Psychological Test. The last mentioned test, also called the Scholastic Aptitude Test, is given to all students before they enroll, and the average score thus far is 120 with a range of 95-175.

1/ College certification grades are determined by each high school but are usually represented by a minimum average of 85 or a B plus.

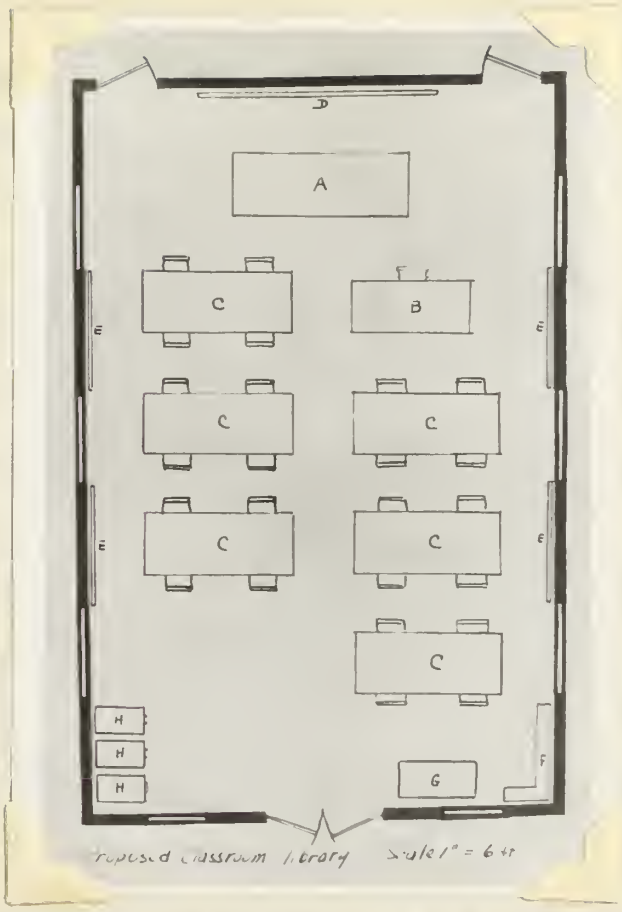
The size of the general chemistry class is large with an average of seventy-five students per lecture group and a total of six lecture groups. The total enrollment in the fall will be 800-900 students of which 120 or less will be taking Chemistry I. This will enable the scheduling of smaller classes.

The present Chemistry Building, Plymouth Hall, was fashioned from a military garage. It contains two identical lecture rooms, fifteen identical laboratories and a stock room.

The lecture room pictured above is used for other courses besides chemistry and the chairs are arranged on raised platforms. The conversion of this room into a classroom-library is therefore impractical. The best solution was to find another classroom. However, this room can be used to advantage for laboratory demonstrations.

This laboratory room can accomodate twenty-five students with adequate space for all necessary individual equipment. A central storeroom eliminates the accumulation of reagents and equipment.

This room was selected as the classroom-library. It is thirty-six feet long and twenty-four feet wide. It is well lighted both artificially and naturally, and is large enough to accomodate the furniture and equipment shown in the diagram on the next page.



Legend:

A. Large demonstration table

B. Teachers desk

C. Student tables, movable

D. Blackboard, the projection screen is mounted above it

E. Bulletin boards

F. Book cases

G. Table for periodicals

H. Filing cabinets

The nature of the unit.-- According to Dr. Billett, teaching includes the selection and organization of subject matter and the criteria for this selection is to be obtained from sound principles of human behavior and from the thorough understanding of the social order of the pupil. When this is accomplished, the resulting plan or method of teaching follows two sequences. (1)"The first sequence will be a statement of changes to be sought in the pupil's capacity for and hence tendencies toward behavior". 1/ (2) The second sequence is the bringing about of these changes by means of guided and directed experiences.

The first sequence is accomplished by giving a verbal statement of the unit 2/ in complete declarative sentences which state the teachers goals in terms of the desired changes that are to be made in the pupil. Although the statement of the unit sets boundaries to the unit, it does not set specific boundaries and hence the unit must be delimited. 3/ This delimitation or itemized statement of the unit serves as specific objectives of classroom instruction.

The second sequence is accomplished by the unit assignment 4/ which is the best tentative preliminary plan of teacher-pupil activity which the teacher can formulate before the beginning of the teaching-learning cycle and which is subject to further development. That part of the unit assignment which all pupils are asked to ac-

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1/ Billett, op. cit., p. 504
2/ Ibid., pp. 505
3/ Ibid., pp. 505-506
4/ Ibid., p. 506

complish, the core activities 1/, is to be mimeographed and distributed to the students as the student's study and activity guide. 2/

As a supplement to the core activities, additional voluntary work is suggested in the form of optional related activities. 3/ These activities are listed by title and posted on the bulletin board. In addition, all the information concerning each activity is typed on a 5 x 8 card and placed in the optional related activities file.

The two source units that follow are organized according to the above.

1/ Billett, op. cit., pp. 507-508
2/ Ibid., p. 508
3/ Ibid., p. 507

CHAPTER II

SOURCE UNIT ON SOME FUNDAMENTALS OF CHEMISTRY

Topics of the Unit

Topic 1: Science, chemistry, elements, compounds, mixtures.

Topic 2: Symbols, formulas, nomeclature, atomic and molecular weights, chemical equations and calculations.

Topic 3: Some gas laws

Topic 4: Valence

General Statement of the Unit

With the knowledge that the properties of a substance are consistent regardless of the time and place - the conditions being the same, the chemist can gather a great amount of data about any particular substance. As a consequence, he can classify that knowledge, formulate laws, put that knowledge to practical use, and employ chemical calculations in his work.

The chemist employs a type of shorthand in the form of symbols, formulas, and equations which make the communication and recording of standard and experimental data rapid, precise, and intelligible to other chemists and people who work with chemistry.

Itemized Statement of the Unit or Delimitation

1. A science is a body of classified knowledge. Chemistry is the science which treats of matter, its composition, and the changes which it undergoes. Although chemistry and physics are called the

physical sciences, they differ in the respect that chemistry is concerned with matter and its changes, and physics is concerned with the energy which matter possess.

2. All matter can be divided into two main headings -- homogeneous substances or heterogeneous mixtures. Mixtures can be further subdivided into coarse mixtures and solutions; and substances can be subdivided into compounds and elements. The following characteristics differentiate mixtures from compounds:

A. Mixture: Does not always have the same composition.

Compound: Always has the same composition quantitatively and qualitatively.

B. Mixture: Each pure substance in the mixture retains its own properties.

Compound: Has only one set of properties.

C. Mixture: Component parts can be separated by mechanical or physical means.

Compound: Component parts can only be separated by chemical means.

D. Mixture: The total chemical energy is equal to the sum of the energies of its parts.

Compound: Has a definite quantity of chemical energy.

3. The physical properties of a material are those characteristics by which it may be identified or distinguished from other material. Chemical properties indicate the capacity (or the lack of capacity) of a material for undergoing complete transformations in which all its properties are altered so that there results a different substance to which we give a different name.

4. Changes in physical properties of a substance are called

physical changes; processes in which substances are converted into other substances with completely different physical properties are called chemical changes.

5. Elements are substances which are not decomposed by ordinary chemical or physical means. Each element or atom can be represented by a symbol. A symbol has both a qualitative and quantitative meaning. It designates an element, one atom of the element, and a gram-atomic weight of that element.

6. Molecules are groups of atoms held firmly together by some type of chemical binding. We recognize three different kinds of molecules: a molecule of an element, a molecule of an electrovalent compound, a molecule of a covalent compound. A formula is made up of symbols showing what atoms and how many of each make up the compound (molecule).

7. The relative weights of the atoms are known as atomic weights: the relative weights of the molecules are known as molecular weights. The basis of comparison in both cases is the atom of oxygen taken as sixteen units (or a molecule of oxygen taken as thirty-two units). The molecular weight is the sum of the weights of the individual atoms which comprise the compound.

8. A (one) gram-atomic weight of an element is the atomic weight of that element expressed in grams: a (one) gram-molecular weight of a compound is the molecular weight of the compound expressed in grams: and a (one) gram-molecular volume of any gas occupies 22.4 liters.

9. Chemical compounds have not all been named according to an exact system, but most of the names indicate the elements present and also the proportion of the elements in the compound. Nomenclature can be discussed under the following headings:

A. Names of compounds containing two elements.

B. Names of compounds containing radicals(a radical has been defined as a group of elements that generally act as a unit in a chemical reaction).

C. Compounds containing three elements.

10. Valence is the combining capacity of the elements. It signifies how many atoms (atomic weights) of one element combine with a definite number of atoms of another element. When atoms are united by actual transfer of electrons, the union is known as electro-valence. The valence number, or simply the valence, of an element, is the number of electrons which it donates, receives, or shares when it combines with itself, another element, or group of elements. For practical purposes, hydgogen is always plus one and oxygen is always minus two.

11. An equation denotes a chemical reaction in terms of symbols and formulas. To be complete, and equation must be balanced; that is, the number and kinds of atoms on one side of the arrow must be the same as on the other. The classes of chemical reactions are:

Direct union or synthesis

Decomposition or analysis

Internal rearrangement

Transfer or displacement

Exchange or double decomposition

Equations are a basis of chemical calculations involving weights,

weights and volumes, and volumes.

12. A discussion of some of the laws of chemistry should include the following:

A. The Law of Conservation of Matter states that matter cannot be created or destroyed; or, the sum of the weights of all the substances that take part in a chemical reaction is equal to the sum of the weights of all substances produced by the reaction.

B. The Law of Definite Proportions states that the proportions (by weight) of the substances that take part in a specific chemical change are definite.

C. The Law of Combining Proportions states that, in all compounds which any element forms, the combining proportions (by weight) of that element can be represented by an experimentally determinded number or by a small integral multiple or sub-multiple of that number.

D. The Law of Multiple Proportions: If two elements form more than one compound, the weight of one which combine with a fixed weight of the other can be represented by a ratio of small whole numbers (integers).

13. The scientific method is based on three fundamental steps: the formulation of a scientific guess or hypothesis by elaborate experimentation and testing to form a theory: and the general acceptance of the theory to make a law.

14. The properties of the physical states of matter (solids, liquids, gases) can be explained by the action of kinectic energy and "Van der Waals" forces.

15. In studying the effect of temperature, pressure, and diffusion on gases, the discussion should proceed along the following headings:

A. Boyles Law--effect of pressure: At constant temperature the volume of a definite weight of a gas and its pressure are inversely proportional.

B. Charles Law--effect of temperature: If the pressure does not change, the volume of a definite quantity of gas varies directly with the Absolute temperature.

C. Combination Law--effect of both pressure and temperature simultaneously.

D. Dalton's Law of Partial Pressure: The partial pressure of each gas in a mixture is proportional to the volume which that gas alone would occupy, if it exerted the same pressure as the whole mixture, at constant temperature.

E. Graham's Law of Diffusion: The rates of diffusion of gases are inversely proportional to the square roots of their densities.

16. Avogadro's Hypothesis states that equal volumes of all gases under the same conditions of molecules. A gram-molecular volume of any gas contains N molecules. (6.02×10^{23}).

Probable Indirect and Incidental Learning Products

1. The student should appreciate the fact that much of the basic principles (fundamentals) of chemistry have been the labor of many men through the centuries. He should also realize that perhaps our present knowledge is merely a scratch on the surface of the vast field called chemistry.

2. The student should assume the attitude of rational-like mindedness as conflicting evidence is brought to light or in the face of apparent fact.

References for Teachers Use Only

1. Hugh S. Taylor, and H. Austin Taylor, Elementary Physical Chemistry, D. Van Nostrand C. Inc., N. Y., 1942.

2. George W. Bennett, Dalton's Law of Multiple Proportions, J. Chemical Education, 10, 21. 1933

3. Herman T. Briscoe, Structure and Properties of Matter, Mc-

Graw-Hill Book Company, Inc., N. Y. 1935.

4. T. H. James, Lecture Demonstration of the Law of Combining Volumes, J. Chemical Education, 12, 87 1935.

5. B. G. Carson, Molecular-Weight Determination for Freshmen, J. Chemical Education, 12, 87 1938.

6. S. S. Hauben, The Derivation of the Names of the Elements, J. Chemical Education, 10, 227 1933.

The Unit Assignment

Books required by the study guide for students' use 1/

1. William McPherson, William E. Henderson, Edward Mack, Jr., and W. Conard Fernelius, Chemistry, A Textbook for Colleges, Ginn and Co., Boston, Mass., 1946.

2. Neil E. Gordon, and William E. Trout, Jr., Introductory College Chemistry, John Wiley and Sons, Inc., N. Y., 1940.

3. Herman T. Briscoe, General Chemistry for Colleges, Houghton, Mifflin Co., Boston, Mass., 1943.

4. Horace G. Deming, Fundamental Chemistry, John Wiley and Sons, Inc., N. Y., 1947.

5. William Foster, Hubert N. Alyea, An Introduction To General Chemistry, D. Van Nostrand Co., Inc., N. Y., 1947.

6. B. Smith Hopkins, General Chemistry for Colleges, D. C. Heath and Co., Boston, Mass., 1942.

7. Albert L. Elder, Textbook of Chemistry, Harper and Brothers, N. Y., 1941.

8. Edwin C. Markham and Sherman E. Smith, General Chemistry Problems, Houghton Mifflin Co., Boston, Mass., 1942.

1/ Example: How is the molecular weight of a compound obtained?
(1, 49-50; 4, 41)
The code means: Text number 1 on the bibliography list, (McPherson, William, William E. Henderson, Edward Mack, Jr., and W. Conard Fernelius, Chemistry, A Textbook for Colleges, pages 49-50 inclusive; and text number 4 on the bibliography list, Horace G. Deming, Fundamental Chemistry, page 41.

Introduction

1. As this is the first unit to confront students who are taking a first course in college chemistry, time should be taken here to accuaint the students with the scope and conduct of the unit. This unit is meant to give an extensive rather than an intensive coverage of the fundamentals of a beginning course in chemistry; and therefore, only the basic aspects of the topics of this unit will be presented and studied. These fundamentals will serve as aids and tools for later units. Since the number of topics is greater than in the other units the time allotted to this unit will be twenty-five classroom hours; and, laboratory demonstrations by the teacher at the beginning of each topic will expedite the coverage of all the topics.

2. The remaining time of the period will be spent in the showing of the following sixteen millimeter films:

Master of Molecules (Revised 1946): 20 min.,

Frontiers of the Future: 10 min. 1/

3. Pretest; same as final test.

Study and Activity Guide 2/

1. The instructor, with the aid of the students, will demonstrate the following exercises taken from the assigned laboratory manual: 3/

1/ Films may be obtained at the cost of postage from Associated Films, 19 So. La Salle St., Chicago, Ill.; and National Association of Manufacturers, 14 W. 49 St., N. Y. 20 N. Y., respectively.
2/ All items marked with an asterisk (*) will be reproduced on the student's study and activity guide.
3/ B. Smith Hopkins, Therald Moeller, and Frank Schrimer Jr., Laboratory and Classroom Exercises in General Chemistry, D. C. Heath and Co., Boston, Mass., 1946.

Exercise No. 4: Properties of Matter

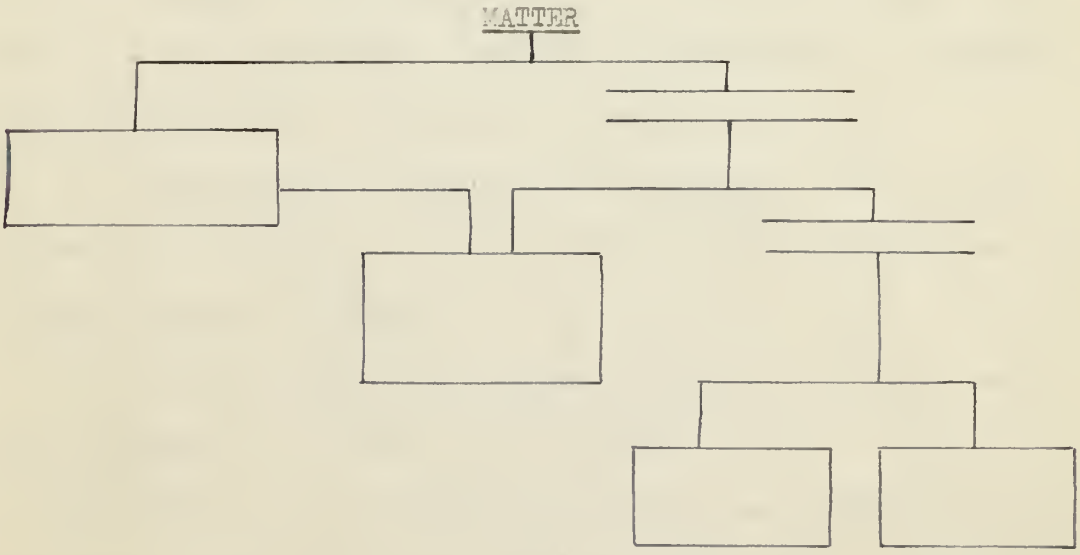
Exercise No. 5: Elements, Compounds, Separation from Mixtures

Exercise No. 6: Study of a Mixture

Exercise No. 7: Chemical Change

*2. What is a science? What is chemistry? To what branch of science does chemistry belong? Show the principal differences between chemistry and physics. How many subdivisions of chemistry can you name? (3, 2-9; 1, 3-9; 5, 2-3)

*3. Fill in the following diagram to show the main categories into which all matter can be placed. (6, 6-8)



*4. In terms of the diagram above, give a suitable definition of a solution. How does a solution differ from a collodial suspension? (4, 11-12)

*5. Using the form below, show the four main differences between mixtures and compounds. (3, 30-32)

MIXTURES	COMPOUNDS
a.	a.
b.	b.
c.	c.
d.	d.

*6. What is meant by a physical property of a substance?; a chemical property? Distinguish between a specific physical property of a substance and the conditions or attributes of a substance. Use definite examples. (5, 32; 3, 19-20; 6, 4; 4, 10-11)

*7. Define physical change, chemical change. Give five examples of each. (5, 33; 4, 10; 3; 21-22) List the five types of chemical change. (4, 26-27)

*8. Define: element and compound. Why can each be classified as a substance? (3, 22-23; 6, 8; 4, 13-14)

*9. State the Law of Conservation of Matter. Explain why the ashes from burning wood weigh less than the original wood. Why the ash which remains when magnesium is burned weigh more than the original metal? (3, 39-40)

*10. State the Law of Definite Proportions. How does this law determine whether a material is a substance or a mixture? In what two ways can the proportion be expressed? (3, 40-41)

*11. When a group of five or more students arrive at this point, the instructor should pause here to summarize with them the main points of Topic 1 in the form of vocabulary and concepts.

Vocabulary: Science, chemistry, physical and chemical properties, attributes, physical and chemical changes, atom, ion, molecule, element, compound, mixture, substance, homogeneous, heterogeneous, electrovalent, and covalent compounds.

Concepts: Law of Conservation of Matter, Law of Definite Composition.

12. A sample of a prescription, similar to the one that a doctor issues to his patients, is placed in the hands of the students and they are asked to read it. The instructor then assumes the role of a pharmacist and makes a meaningful interpretation. The class is then asked to read other samples.

With the aid of a symbol chart, the instructor can demonstrate the symbolism of chemistry until the students become familiar with the symbols of the most common elements. On the blackboard, symbols are placed together forming compounds which are represented by formulas.

*13. What symbols did the alchemists use to represent the known elements of their time? Why did they use them? In our present system of symbols, the initial letter of certain elements is used. List these elements and their symbols.

Because several names begin with the same letter, it is often necessary to add a second letter to the first. List all the elements that begin with C with their respective symbols.

Some elements derive their symbols from their Latin names. List six of these elements with their symbols. State the qualitative implications of a symbol. (1, 39; 5, 25-26; 4, 38-39; 6, 11)

*14. Some of the names of the elements have their origin in one of the following categories; give examples of each:

Origin	Examples
(a) Unknown origin	
(b) What they do	
(c) Physical and chemical properties	
(d) Mythology	
(e) Countries	
(f) States	

*15 What are the qualitative and quantitative implications of a formula?

*16. Scientists cannot as yet weigh the individual atoms. What does the term atomic weight of an element actually mean? Describe the physicist's method of determining atomic weights. What standard is used? (1, 45-49)

*17. How is the molecular weight of a compound obtained? (1, 49-50; 4, 41) Calculate the molecular weights of the following compounds:

(a) HCL_____ (c) N_2O_5_____ (e) NH_4NaHPO_4_____

(b) PCL_3_____ (d) Na_3PO_4_____ (f) $CuSO_45H_2O$_____

(g) $3MgO \cdot 4SiO_2 \cdot H_2O$_____

*18. How is the percentage composition of a compound calculated? (1, 50-51) Refer to 8, 74-76 for additional problems.

*19. What is meant by the gram-atomic weight of an element; a gram-molecular weight of a compound? (1, 54-59) How many grams are there in:

(a) 1 gram-atomic weight of oxygen?

(b) 2 gram-atomic weights of oxygen?

(c) 1 gram-molecular weight of sulfur dioxide (SO_2)?

How many pounds are there in 2 pound-molecular weights of water? (H_2O)

20. When a group of five or more students arrive at this point, the instructor should pause to summarize the main points of Topic 2 in the form of vocabulary, concepts, and calculations.

Vocabulary: Symbol, formula, atomic weight, molecular weight, weight standard, gram-atomic weight, and gram-molecular weight.

Concepts: Nomenclature, the qualitative and quantitative implications of a symbol and a formula, the relative weight or atomic weight.

Calculations: Determination of the molecular weight of a compound, and the determination of the percentage composition of a compound.

21. The instructor with the aid of students will demonstrate Exercise No. 36 in the assigned laboratory manual.

*22. What is the approximate gram-molecular volume of any gas

at S.T.P.? How many molecules (Avogadro's Number) are there in one gram-molecular weight of any compound? (4, 3[illegible]; 3, 160; 4, 125-126; 1, 54-58) Fill in the following form:

Compound	Mol. Wt.	Gr. Mol. Vol.	Avogadro's No.
NH_3			
CO_2			
SO_2			
N_2O_5			

*23. Starting with the weight of any volume of a pure gas at any pressure and temperature, show by word picture how you would determine the molecular weight of the gas? How can the molecular weights of some solids and some liquids be determined?

*24. A liter of each of three gases at S.T.P. weighs 0.178 g, 2.85 g, and 6.87 g respectively. Calculate the molecular weights of the three gases.

*25. What is an equation? When is an equation balanced? (3, 185-190; 4, 48-50) In the following equation:

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

What weights of $KClO_3$, KCl, and O_2 are represented? What volume of O_2 is represented? Using these weights relationships as a pilot ratio (1, 29) how many grams of oxygen can be obtained by the complete decomposition of ten grams of Potassium Chlorate? (1, 91; 4, 50-51)

Using the above formula weight-volume relationships, how many liters of oxygen can be obtained from the complete decomposition of 100 g. of potassium chlorate? (1, 91-92)

*26. What name do chemists give to a compound containing only two elements? Which element is mentioned first? With what letters does the second name end? If two elements form more than one compound, how are they named? What rules are evident for compounds containing a radical? How are compounds named which contain three elements but no radical? (1, 321; 2, 127-128; 3, 200-2-2; 5, 27-29; 7, 95-101) Name the compounds in (2, 128)

27. The following points are to be discussed by a group of five or more students when they arrive at this point as a review of Topic 3: Avogadro's number, gram-molecular volume, weight of a liter of gas, what an equation represents, and using the formula for weight, and weight-volume relationships.

28. The instructor will demonstrate that portion of Exercise No. 18 in the assigned laboratory manual which is concerned with Charles' Law. A group of students will demonstrate that portion of Exercise No. 18 which is concerned with Boyle's Law. The instructor will then demonstrate Dalton's Law of Partial Pressure 1/, and Graham's Law of Diffusion. 2/

*29. What are the three physical states of matter? How can each physical state be explained in terms of "kinetic" and "Van der Waals" forces? (1, 114)

1/ Text number two of the selected bibliography, p. 121

2/ Fernelius, Mack, and Quill, Laboratory Exercises in General Chemistry, Ginn and Co. Inc., Boston, Mass., 1946.

*30. What are the characteristics of the gaseous state of matter? (1, 62-63; 4, 105-107)

*31. State Boyle's Law. What is meant by the term "inversely proportional"? Without using the physical formula $P_1V_1=P_1V_1$, how can a change in volume be represented mathematically if the pressure is altered and the temperature remains the same? What is an (One) atmosphere? How may it be represented in the c-g-s system? What are the standard conditions of temperature and pressure (S.T.P.)? (2, 98-100; 8, 33-34) Try additional problems in (8, 35 exercises 47-56).

*32. State Charles' Law. What is absolute temperature? How can centigrade readings be converted to absolute readings? Without using the physical formula $V_1T_2 = V_2T_1$, how can a change in volume be represented mathematically if the absolute temperature is altered and the pressure remains the same? (8, 27-30; 2, 95-98) Try additional problems in (8, 31 exercises 41-46).

*33. How can the Laws of Charles and Boyle be applied simultaneously? Without using the physical formula $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$, how can a change in volume be shown when both the pressure and obsolute temperature vary? What other law is derived from this law? (2, 100; 8, 37-38) Try additional problems in (8, 39-40 exercises 57-65).

*34. State Dalton's Law of Partial Pressure. How does it apply to the air as a mixture? Many gases when prepared in the laboratory are collected over water, reference (1, 88). What other gas is pre-

sent besides oxygen? What pressure would the oxygen exert if it were alone in the container? Refer to the water vapor or aqueous tension tables in the appendix. (2, 102-104; 1, 71-72; 8, 45-46). Do problems number 72, 73, 75 in (8, 47).

*35. State Graham's Law of Diffusion. What is the most important factor to keep in mind where the rate of diffusion is concerned? If ammonia gas is placed at one end of a 10 cm glass cylinder, and hydrogen chloride gas is placed at the other end simultaneously, where would the white ring of ammonium chloride be formed? What would be the effect of placing soft tennis balls in a vessel filled with hydrogen? (5, 121-122; 3, 119-120; 1, 72-73).

36. Time should be taken here to review the gas laws and the calculations involved when a group of five or more students arrive at this point.

37. Students are asked to examine their individual student valence kits. 1/ With the aid of the instructors valence kit and the blackboard, the instructor will demonstrate how the kit functions.

*38. Give a general definition of valence. What is meant by covalence and electrovalence? In the case of electrovalence, how are the valence numbers represented? Can positive and negative valence numbers be exhibited in covalency? (2, 41) Does an elect-

1/ Kits can be ordered from the Central Scientific Co., Boston, Mass.

rically neutral atom have a valence, or does it acquire a valence only after it has become associated with another atom or radical? How is the valence of a radical determined? (2, 129-131; 1,43-45; 2, 167-172; 3, 180-184; 4, 193-196)

*39. Considering hydrogen as always + 1 and oxygen as always - 2, find the valences of all the other elements and radicals in the compounds listed in (2, 130 exercise 2). Fill in the chart on (6, 104).

Optional Related Activities

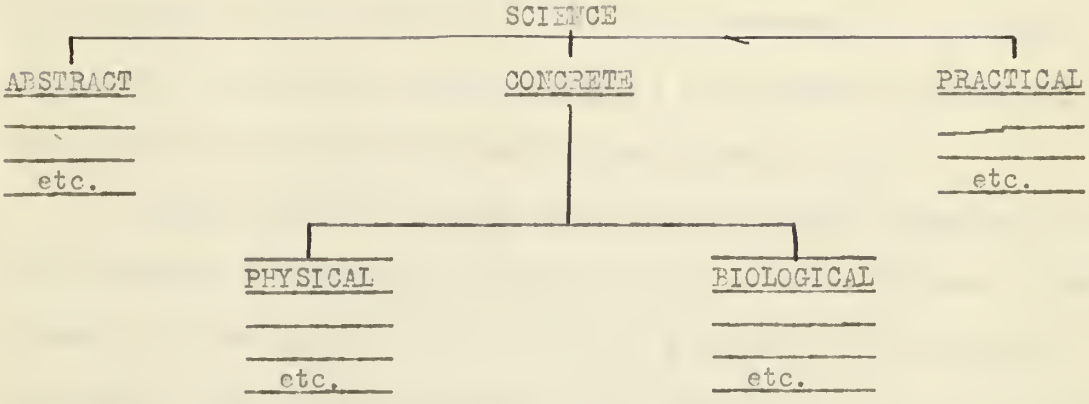
1. Visit the stock room of your chemistry laboratory and make a list of all the elements there under the following headings:

Elements seen previously			Elements never seen previously		
Element	color	physical state	Element	color	physical state

2. Make a list of fifty (50) forms of matter from your personal possessions and items in your dormitory room, and tell whether they are mixtures or substances. Make the list from random samplings and then place the items in their respective categories. From your observations, what conclusions can be drawn as to the majority of natural and artificial objects in their classification as to mixtures and substances?

3. Make a list of twenty-five (25) physical changes and twenty-five (25) chemical changes that you may encounter during the course of a day. Also make an indefinite list of changes of which you are not certain as to whether they are physical or chemical changes.

4. With the aid of the science faculty and others, compile a nearly complete list of sciences and place them in their proper position in the chart below:



All the subdivisions of a science should be listed under that science.

5. The names of the elements have been derived through the centuries. Show the derivation of the names of all the elements on the following form. (Suggested form appears on the back of the 5 x 8 card)

Name of elements	Symbol	Derivation of name
Hydrogen	H	From chemical properties, means 'water former'
etc.		

The names should be listed in alphabetical order; and if possible, the date of discovery should be included. See instructor for references.

6. Explain what happens when an automobile tire "blows-out"; and when a gas filled balloon is freed from its mooring. Diagrams and pictures as well as a written description of each situation are

necessary for a report to the class. The diagrams and pictures should be of the 4 x 5 size for use in the opaque projector.

7. If we were suddenly to bring an intelligent man as Benjamin Franklin back to life and show him an automobile in running condition, how could he describe (with a fair degree of accuracy) what was going on under the hood without looking at it?

8. Make a set of drawings showing the internal arrangement of two elements, two compounds, two mixtures, and two solutions. These drawings are to be made on 4 x 5 or 5 x 8 cards so that they may be used in the opaque projector as study aids.

9. An Atom and Molecule kit is available in the filing cabinet under drawer labeled "Visual Aids". Construct the atomic pattern of ten atoms and make individual drawings of each of them on 5 x 8 cards. Photographs may be substituted in place of drawings and should be of the 5 x 7 size.

10. An Atom and Molecule kit is available in the filing cabinet in the drawer labeled "Visual Aids". Construct the molecular pattern of ten molecules and make individual drawings on 5 x 8 cards. Photographs may be substituted for drawings and should be of the 5 x 7 size.

11. An Atom and Molecule kit is available in the filing cabinet in the drawer labeled "Visual Aids". Construct the atomic pattern of ten radicals and make individual drawings on 5 x 8 cards. Photographs may be substituted for the drawings and should be of the 5 x 7 size.

12. Submit a report or reports on current newspaper or magazine articles which are the concern of this unit. The report should be brief and contain the following information:

(a) Name of the article

(b) Author

(c) Date of publication

(d) Name of publication

(e) Summary of article

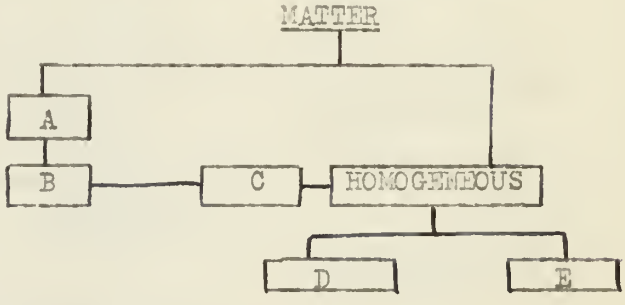
(f) Your comments or reaction

All reports are to be written or typewritten on regular typewriter size paper and submitted in a folder.

PRE-TEST AND FINAL TEST
UNIT... SOME FUNDAMENTALS OF CHEMISTRY

A. Directions: Each letter in the diagram can be answered by one choice of the suggested answers in the left column. Indicate your choice by placing the letter in the diagram into the parenthesis in front of your choice. (Leave 3 parenthesis blank)

1. ( ) Mixtures
2. ( ) Homogeneous
3. ( ) Elements
4. ( ) Heterogeneous
5. ( ) Compounds
6. ( ) Solutions
7. ( ) Colloids
8. ( ) Suspensions



B. Each letter in the right column can be answered by one choice of the suggested answers in the left column. Indicate your choice by placing the letter of the blank into the parenthesis in front of your choice. (Leave six parenthesis blank)

9. ( ) Sodium, Ammonia, Hydrogen, Phosphate
10. ( ) Sodium PerChlorate
11. ( ) Sodium Oxide
12. ( ) Sodium Sulfate
13. ( ) Sodium Peroxide
14. ( ) Sodium Chlorite
15. ( ) Sodium Sulfite
16. ( ) Sodium Chloride
17. ( ) Sodium Carbonate
18. ( ) Sodium Hypo-Chlorite
19. ( ) Sodium Chlorate
20. ( ) Sodium Bi-Carbonate
21. ( ) Sodium, Ammonium, Hydrogen, Phosphate

A. NaCl
B. Na_2O_2
C. Na_2CO_3
D. Na_2SO_3
E. NaClO
F. NaClO4
G. $Na(NH_4)H(PO_4)$

C. Directions: Same as B. (Leave 3 parenthesis blank)

22. ( ) The sum of the weights of all substances that take part in a chemical reaction is equal to the sum of the weights of all the substances produced by the reaction.

23. ( ) The weight of copper that combines with 16 g. of oxygen in one compound is 63.6 g.; in a second compound it is 127.2 g. The ratio of the weights of oxygen and copper that combine can be expresses as follows.
$\frac{1 \times 63.6}{1 \times 16}$ and $\frac{2 \times 63.6}{1 \times 16}$

24. ( ) When hydrogen and oxygen react to form water, 1.008 g. of hydrogen combines with 8 g. of oxygen to form 9.008 g. of water. If 16 g. of oxygen is used, 2.016 g. of hydrogen is required for the complete reaction.

25. ( ) The number of grams of an element that will combine with 8 g. of oxygen.

26. ( ) In the two oxides of carbon, (CO and CO_2), it is found that the weights of carbon which combine with 16 g. of oxygen are 12 and 6 g. respectively. These weights of carbon are in the ratio of 2:1.

27. ( ) Energy cannot be created or destroyed.

A. Law of conservation of matter.

B. Law of definite proportions.

C. Law of combining proportions.

D. Law of multiple proportions.

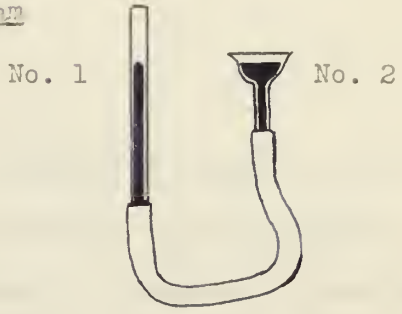
D. (Leave eight parenthesis blank)

28. ( ) Gram
29. ( ) Formula
30. ( ) Specific
31. ( ) Element
32. ( ) Symbol
33. ( ) Qualitative
34. ( ) Gram-atomic weight
35. ( ) Coordinate compound
36. ( ) Non-specific
37. ( ) Quantitative
38. ( ) 1
39. ( ) 16
40. ( ) 16 g.
41. ( ) 32
42. ( ) 32 g.
43. ( ) 22.4 g.

Each element or atom can be represented by a (A) which has both a (B) and a (C) meaning. It designates one (D) of that element. There are three different kinds of molecules; a molecule of an electrovalent compound, a molecule of a covalent compound and a molecule of a (an) (E). The molecular weight of oxygen is (F); the gram-molecular weight of oxygen gas is (G). The basis for comparison for the relative weights of the atoms is oxygen taken a (H) units.

E. (Leave three parenthesis blank)

Diagram



44. ( ) Gay Lussac's
45. ( ) Boyle's
46. ( ) Charles'
47. ( ) Remain the same
48. ( ) Fall
49. ( ) Rise
50. ( ) Increase
51. ( ) Decrease

If the movable tube (#2) is raised, the level of the mercury in the stationery tube (#1) will (A). This means that the pressure on the gas in tube #1 has been (B); therefore, the volume has been (C). If the tube #2 is lowered, the level in tube #1 will (D). This apparatus demonstrates (E) Law.

F. Directions: When the valence of the underscored atom, ion or radical is determined, place that number in the parenthesis provided.

52. ( ) H ($\underline{NO_3}$)
53. ( ) Na_2 ($\underline{CrO_4}$)
54. ( ) $K_2\underline{S}$
55. ( ) $\underline{NH_4}$ Cl
56. ( ) $\underline{As}$ Cl_3
57. ( ) $\underline{Al_2}$ O_3
58. ( ) K_2 ($\underline{CrO_4}$)
59. ( ) $\underline{Ag_2}O$
60. ( ) H_2 $\underline{Si}$ O_3
61. ( ) Na_2 H $\underline{PO_4}$
62. ( ) $H_3\underline{P}$ O
63. ( ) K_2 $\underline{Te}$ O_4
64. ( ) H_2 $\underline{Se}$ O_3
65. ( ) K_2 $\underline{Cr_2}$ O

G. If the following forms of matter signify a compound, place a "C" in the parenthesis before the substance; if they signify a mixture, place an "M" in the parenthesis. (Leave no parenthesis blank)

66. ( ) Milk
67. ( ) Wood
68. ( ) Diamond
69. ( ) Steel
70. ( ) Glass
71. ( ) Water (HOH)
72. ( ) Carbon
73. ( ) Sugar
74. ( ) Coffee
75. ( ) Gun powder
76. ( ) Concrete

H. Mark the following statements with a "P" if they indicate a physical change or with a "C" if they indicate a chemical change. (Leave no parenthesis blank)

77. ( ) Formation of dew
78. ( ) Souring of milk
79. ( ) Magnetization of iron
80. ( ) Digestion of food
81. ( ) Dissolving of sugar in water
82. ( ) Decay of vegetable matter
83. ( ) Rusting of iron
84. ( ) Liquification of air
85. ( ) Paint

I. Multiple Choice: Each item consists of a question or an incomplete statement that can be answered or completed correctly by one of the five lettered choices given. Indicate your answers by placing the capital letter of your choice in the parentheses provided for each item on the answer sheet below:

ANSWER SHEET

86. ( )	90. ( )	94. ( )	98. ( )	102. ( )
87. ( )	91. ( )	95. ( )	99. ( )	103. ( )
88. ( )	92. ( )	96. ( )	100. ( )	
89. ( )	93. ( )	97. ( )	101. ( )	

---

86. When the following equation is balanced, what number appears in front of TeO_3?

Equation: $_____ H_2TeO_4 \rightarrow _____ H_2O + _____ TeO_3$

(A) 3
(B) 4
(C) 1
(D) 12
(E) None of these

87. Two pound-atomic weights of hydrogen is:

(A) 11.2 liters (C) 22.4 liters (E) 44.8 liters
(B) 1 liter (D) 2 liters

88. One gram of hydrogen gas occupies the following volume at S.T.P.:

(A) 11.2 liters
(B) 1 liter
(C) 22.4 liters
(D) 2 liters
(E) 44.8 liters

89. When the following equation is balances, what number appears in front of O_2?

Equation: ____C_5H_{12} + ____O_2 ⟶ ____CO_2 + ____H_2O

(A) 5
(B) 8
(C) 11
(D) 17
(E) None of these

90. The molecular weight of NaH_3PO_4 is:

(A) 136
(B) 135
(C) 120
(D) 68
(E) 34

91. The following is an example of one of the listed types of reactions:

Equation: $Br_2 + 2HI \longrightarrow I_2 + 2HBr$

(A) Direct union or synthesis
(B) Decomposition or analysis
(C) Internal rearrangement
(D) Transfer or displacement
(E) Exchange or double decomposition

92. Ten gram-molecular weights of ozone (O_3) is:

(A) 10 g
(B) 160 g
(C) 480 g
(D) 960 g
(E) 320 g

93. It is desired to collect 1 g of gas in the laboratory at 740 mm pressure and 20 degress C. At S.T.P., one gram of the gas occupies 500 cc. One of the following indicates the mathematics involved:

(A) $500 \times \frac{760}{740} \times \frac{273}{293}$

(B) $500 \times \frac{760}{740} \times \frac{293}{273}$

(C) $500 \times \frac{740}{760} \times \frac{293}{273}$

(D) $500 \times \frac{740}{760} \times \frac{273}{293}$

(E) $500 \times \frac{760}{740} \times \frac{20}{0}$

94. 500 cc. of a gas is collected at 20 degrees C and 760 mm pressure. What will be the volume of the gas at S.T.P.,? Which of the following indicated solutions is correct?

(A) $500 \times \frac{273}{293}$

(B) $500 \times \frac{293}{273}$

(C) $500 \times \frac{76}{20}$

(D) $500 \times \frac{273}{760}$

(E) $500 \times \frac{760}{293}$

95. 150 cc. of a gas is collected over water at 720 mm. pressure and 10 degrees C. What will be the volume of the dry gas at the same temperature and pressure? Which of the following indicated solutions is correct?

(A) $150-(150 \times \frac{720}{713}$

(B) $150-(150 \times \frac{720}{760}$

(C) $150-(150 \times \frac{713}{720}$

(D) $150-(150 \times \frac{713}{720}$

(E) None of these

96. One of the following gives the percentage composition of hydrogen in $HC_2H_3O_2$:

(A) $\frac{60}{4} \times 100$

(B) $\frac{4}{60} \times 100$

(C) $\frac{3}{60} \times 100$

(D) $\frac{1}{60} \times 100$

(E) $\frac{60}{3} \times 100$

97. Which will diffuse faster through a small opening, oxygen (O_2) or ammonia gas (NH_3)?

(A) Ammonia gas because it has a lower boiling point.
(B) Oxygen because it is an element.
(C) Oxygen because it has only two atoms per molecule.
(D) Ammonia because it has a lower molecular weight.
(E) Oxygen because it is more nearly a perfect gas.

98. At S.T.P., 6.02×10^{23} molecules of H_2S were prepared. The substance weighs:

(A) 17 g
(B) 11.2 g
(C) 22.4 g
(D) 34 g
(E) None of these

99. Thirty-four grams of ammonia gas (NH_3) occupies the following volume at S.T.P.

(A) 22.4 liters
(B) 44.8 liters
(C) 2 liters
(D) 34 liters
(E) 11.2 liters

100. The equation $AgNO_3 + NaCl \longrightarrow AgCl + NaNO_3$ is an example of one of the following types of reactions:

(A) Direct union or synthesis
(B) Decomposition or analysis
(C) Internal rearrangement
(D) Transfer or displacement
(E) Exchange or double decomposition

101. Given the equation $C + O_2 \longrightarrow CO_2$, what weight of carbon reacts with two gram-molecular weights of oxygen?

(A) 1g
(B) 2 g
(C) 12 g
(D) 24 g
(E) 4 g

102. What weight of carbon dioxide is formed by the complete burning of three grams of carbon?

(A) 10 g
(B) 11 g
(C) 12 g
(D) 4 g
(E) 3 g

103. What volume of oxygen is necessary to obtain 10 liters of carbon dioxide?

(A) 16 liters
(B) 32 liters
(C) 1 liter
(D) 2 liters
(E) 10 liters

CHAPTER III

SOURCE UNIT ON THE ATOM

Topics of the Unit

This unit is concerned with the following topics: (Atomic structure; periodic classification of the elements; radio activity; isotopes.

General Statement of the Unit

By definition, chemistry is concerned with matter, its composition, and the changes which it undergoes. All matter is divided into fundamental building blocks called elements. These elements in turn are made up of atoms, and the atoms are further divided into smaller particles. A thorough understanding of the make-up of these individual atoms, how they are alike and different, the periodic relationship that exists among them, and the changing of one atom into another by artificial and natural transmutation will be the basis for insight of the fundamental and advanced study of chemistry.

Itemized Statement of the Unit or Delimitation

Atomic structure

1. Before 1800, it was proposed and generally believed that the atom was the smallest particle of matter. (Dalton's Atomic Theory)

2. During the nineteenth century, chemists and physicists

were content to regard atoms, as hard, elastic, round, dense, unchanging particles.

3. Early in the twentieth century, it was clearly realized that the characteristic properties and behavior of atoms must mean that various species possess characteristic structures which determine their properties.

4. Since the largest atoms cannot be seen in the most powerful microscope, we must give up all hope of direct observation and resort to inference and deduction in our attempt to understand the manner in which an atom is put together. The picture we get in this way we call a "theory of atomic structure".

5. It seems, at present, that there are five component parts out of which atoms are built:

A. The proton

B. The neutron

C. The electron

D. The positron

E. The alpha particle

6. A rough plan of atomic structure bears a striking formal resemblance to certain kinds of nuts in the sense that both possess kernels and shells. The shell contains the electrons; and the kernel or nucleus contains the other particles. There is also a formal resemblance to our solar system. The sun is the nucleus, the planets are the electrons.

7. In the study of the nucleus, the following items should be taken up at some length:

A. The behavior of atoms bombarded with alpha particles.

B. The behavior of atoms bombarded with electrons

C. The existence of isotopes

D. Implications toward radio activity

8. In the study of the shell, discussion should follow these lines of evidence which are helpful in forming a theory about the positions of the electrons:

A. Spectroscopic behavior

B. Periodic table behavior

C. Chemical combination

9. The atom itself is a great source of energy when disintregration is brought about either naturally or artificially.

10. Natural radio activity is different mechanically from artificially produced transmutation.

Periodic classification of the elements

11. Among the works of man there is no more beautiful example of our definition of science as a classified and organized body of knowledge than the classification of the elements.

12. Early attempts at classification are centered around the efforts of Dobereiner in 1829, Newlands in 1865, and Mendeleeff in 1869.

13. The periodic chart as developed by Mendeleeff bears a striking resemblance to our present day chart.

14. Mendeleeff's periodic law is based upon atomic weights while our present day classification is based upon atomic numbers.

15. Mendeleeff's predictions were a basis for universal adoption.

16. The periodic charts of today are divided into vertical groups and families, and are divided horizontally into periods and rows.

17. The uses of the periodic table are as follows:

A. It allows the elements to be studied in groups.

B. It is a basis for prediction of new elements.

C. It stimulates more accurate determination of atomic weights.

D. It is of value in checking the properties of elements.

E. It encourages the search for new elements.

18. In the study of the Hubbard Chart, the following items should be considered:

A. The change of properties within a group

B. The change of properties within the horizontal periods

C. The transitional elements

D. Valence of each group toward hydrogen

E. Valence of each group toward oxygen

F. The diagonal line

G. Oxidation and reduction

H. Determination of the exact number of electrons in each planetary level.

Radio Activity

19. The discovery and early work of radio activity is centered around the experimental efforts of Antoine Becquerel and Pierre and Marie Curie.

20. The existence of the tree types of rays (alpha, beta, and gamma) was proved by Rutherford.

21. The nature of these rays can be discussed in terms of:

A. Identification as to ray or particle

B. Charge

C. Penetrating quality

D. Effect on a photographic plate

22. Radio activity is aseries of decompositions and disintegrations. Each element can only give off one particle to become a new element or a subdivision of that element.

23. Radio active elements assume a definite position on the periodic table as transmutation takes place.

24. Radio activity can be interpreted in terms of atomic structure in that the alpha and beta particles existed in the atom before their emission, and hence, were definite particles within its structure.

Isotopes

25. The study of isotopes is an attempt to explain fractional atomic weights.

26. Isotopes of any one element have the same atomic number but different atomic weights.

27. Isotopes differ from allotropic forms in that the former indicates the same atom but with different atomic weights, while the latter indicates the same atom but in different physical forms.

28. Isotopes of any one element are functions of the number of neutrons in the nucleus.

Probable Indirect and Incidental Learning Products

1. It is hoped that there may be an appreciation of the background and experimental work of both chemists and physicists in the development of our present atomic theory as regards atomic structure, classification of the elements, radio activity, and isotopes.

2. There should be an attitude of respect for the importance of the scientific method as applied to the development of the present atomic theory and the realization that it is a tentatively accepted plan until it is proven right, wrong, or until it is modified in the light of more convincing evidence.

List of References for Teacher's Use Only

1. Joel H. Hildebrand, Principles of Chemistry, The MacMillan Co., N. Y., 1947.

2. Herman T. Briscoe, Structure and Properties of Matter, McGraw-Hill Book Co., N. Y., 1935.

3. John K. Robertson, Atomic Artillery and the Atom Bomb, D. Van Nostrand and Co., Inc., N. Y., 1945.

4. Physics Staff, University of Pittsburg, Pa., Atomic Physics, John Wiley and Sons, Inc., N. Y., 1947.

5. Hausmann, Erich, and Edgar P. Slack, Physics, D. Van Nostrand, Inc., 1947.

6. The following publications from The National Committee on Atomic Information:

   A. William A. Higinbotham, and Ernest K. Lindley, Atomic Challenge, 35¢.

   B. Atomic Scientists Of Chicago, The Atomic Bomb.

   C. McGraw-Hill Publishing Co., Men vs. Atom- Year 1, 1946.

   D. National Committee, The Atom Goes To Work For Medicine, 25¢.

The Unit Assignment

Books required by the study guide for students' use 1/

1. William McPherson, William E. Henderson, Edward Mack, Jr., and W. Conard Fernelius, Chemistry, A Textbook for Colleges, Ginn and Co., Boston, Mass., 1946.

2. AlbertL. Elder, Textbook of Chemistry, Harper and Brothers, New York, N. Y., 1941.

3. Neil E. Gordon, and William E. Trout, Jr., Introductory College Chemistry, John Wiley and Sons, Inc., New York, N. Y., 1940.

4. Herman T. Briscoe, General Chemistry for Colleges, Houghton Mifflin Co., Boston, Mass., 1943.

5. Eugene P. Schoch, William A. Felsing, And George W. Watt, General Chemistry, McGraw-Hill Book Co., Inc., New York, N. Y., 1946.

6. Horace G. Deming, Fundamental Chemistry, John Wiley and Sons, Inc., New York, N. Y., 1947.

7. John A. Timm, General Chemistry, McGraw-Hill Book Co., Inc., New York, N. Y., 1944.

1/ Example: What is Prout's Hypothesis (10, 297-298; 2, 35) The code means; text number 10 on the bibliography list (Schlesinger F. I., General Chemistry, pp. 297 to 298 inclusive; and text number 2 on the bibliography list (Elder, Albert L., Textbook of Chemistry, p. 35.

8. William Foster, and Hubert N. Alyea, An Introduction To General Chemistry, D. Van Nostrand Co., Inc., New York, N. Y., 1947.

9. B. Smith Hopkins, General Chemistry for Colleges, D. C. Heath and Co., Boston, Mass., 1942.

10. H. I. Schlesinger, General Chemistry, Longmans, Green and Co., New York, N. Y., 1943.

11. Stuart R. Brinkley, Introductory General Chemistry, The MacMillan Co., Boston, Mass., 1943.

Study Guide

Introduction

1. With the aid of an opaque projector, the instructor can supplement a brief review of the history of human thought and experimentation concerning the atom. Starting with Dalton's Atomic Theory suitable charts, drawings, pictures, and diagrams can be projected to show how the conception has changed and what the latest theories are today. (20 minutes)

2. The last thirty minutes will be devoted to the showing of the 16 mm film, Development of Atomic Structure, or its equivalent. 1/

3. Pretest. (same as final test)

Students' Study Guide 2/

1. State briefly the main points of Dalton's Atomic Theory. How was the atom characterized then? Criticize each postulate as to validity according to present-day thinking. (1, 17-19; 2, 62-71)

1/ This film is made available by The Information On Atomic Energy Committee of The Atomic Energy Commission, Washington, D. C. at the cost of postage.
2/ To be reproduced on mimeograph stencil and distributed to every student.

2. What are the five component parts of an atom? List each component on a chart under the vertical headings:

A. Name

B. Charge

C. Mass (O= 16)

D. Where found (source)

E. Possible composition

What is meant by the 'packing effect'? (3, 332-333; 4, 250-252)

3. Which is the larger, a protron or an electron? (7, 250)

4. Explain the statement, an Alpha particle is an ion of helium.

5. Draw and label a rough plan of atomic structure showing the nucleus and the planetary electrons. To what can an analogy be refered? In there a space between the nucleus and the shell? (6, 270)

6. When an atom is bombarded with alpha particles, what part does the nucleus play? Do the outer electrons have any affect on the alpha particles? What supposition can be derrived from this? Who conducted the above experiments? (1, 230-232)

7. How are X-rays produced? Who conducted the first successful experiments on X-rays? What is the correlation between X-rays analysis of the elements and their atomic numbers? (1, 232; 4, 256-260)

8. What is the role of the neutron in the tentative theory of atomic structure? How does it explain the difference between

the atomic number of an element and its atomic weight? (1, 232-233; 4, 256-260)

9. Show diagramatically the nuclear composition of the first ten atoms on the periodic table. (1, 233)

10. Define the term isotope. The isotopes of magnesium are of isotopic weights 24, 25, and 26. In what respects are they alike, and in what respects are they different? (1, 233-234)

11. Show by diagram how isotopes are separated by a mass spectrograph. (3, 334-335)

12. Why do many elements have atomic weights that are not integers? (1, 233-234)

13. Explain whay isotopes should have the same chemical properties. What is the difference between the terms isotope and allotropic form? (1, 29)

14. What are the isotopes of hydrogen?, of oxygen? By writing formulas, show the number of possible types of water that can exist. (2, 42-43; 3, 354-355; 4, 250-251)

15. The atomic weights of the isotopes of an element, whose atomic number is 38, are 88, 87, 86. What is the nuclear composition of each of the isotopes?

16. Argon, (atomic number 18, atomic weight 39.994) consists of two isotopes of mass numbers 39 and 41. In what ratio are these isotopes present in argon?

17. Outline the Bohr Theory of atomic structure. How does it differ from other theories? By what theory has it been replaced? (6, 274; 2, 53-55)

18. Why is the first electron set considered complete when it contains two electrons? Why is the second set considered complete when it contains eight electrons?

19. What is meant by the term electrovalence and covalence? (2, 58-61; 6, 286-290)

20. In terms of the formulae of non-polar compounds and their electronic interpretations, what is meant by single, double, and triple bonds?

21. Account for the inertness of the inert gases. (3, 257; 6, 275-276)

22. Show by diagram the union of an atom of sodium and an atom of chlorine to form the molecule sodium chloride. Is the molecule electrovalent or covalent?

23. Draw diagrams showing the arrangement of electrons for the following compounds and ions: (6, 285-293)

A. Chloroform.....$CHCl_3$

B. Phosphorus trichloride.....PCl_3

C. Sulfur dioxide.....SO_2

D. Carbon tetrachloride.....CCl_4

E. The perchlorate ion.....(ClO_4 -1)

F. The sulfate ion.....(SO_4 -2)

24. What is Prout's Hypothesis? (10, 297-298; 2, 35)

25. State Mendeleeff's periodic law. Show that it is not entirely valid as he stated it. (4, 209-211; 10, 312; 11, 210-213)

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26. How are X-rays produced? Who conducted the first successful experiments on X-rays? What is the correlation between X-ray analysis of the elements and their atomic numbers? State the periodic law in terms of the above. (1, 207-208; 9, 47)

27. What are the advantages or uses of the periodic table? (1, 213-215; 4, 215-216; 11, 206-210)

28. What is the meaning of the following terms as applies to the periodic table: group, family, short period, and long period? (1, 211-212; 4, 212)

29. Name all the elements in three families and all the elements in one period.

30. Where on the chart are the rare-earth elements found? Are all of them truly rare-earth elements?

31. What other elements possess the same external group of electrons as neon? What name is given to this group of elements?

32. Define oxidation and reduction in terms of the electron theory. Where on the periodic chart are the best reducing agents found? The best oxidizing agents? (10, 306-308)

33. How do the properties of the elements change on the periodic chart: (4, 215)

A. from left to right:

(1) with regard to metallic characteristics

(2) with regard to non-metallic characteristics

B. from top to bottom:

(1) with regard to metallic characteristics

(2) with regard to non-metallic characteristics

34. What determines whether an element is termed a metal or a non-metal? Where are the metals located on the periodic table? the non-metals? What elements occur between them? Which is the most active metal? Non-metal? (4, 215; 6, 276)

35. What are valence electrons? How many valence electrons are there for each close family of every group? Show the valence of each group toward hydrogen, toward oxygen. (4, 214; 6, 258-259; 9, 48; 10, 347)

36. Why does Fluorine not show a valence of plus seven (+7) as does chlorine?

37. In what possible ways may atoms unite to form compounds? (1, 240-245; 4, 267-271; 5, 183-189; 6, 281-296; 7, 272-282; 9, 30-35; 10, 345-358)

38. Considering the position of the elements on the periodic chart and the structure of their atoms, which of the following compounds would you select as covalent, and which as electrovalent? $CaCl_2$, $SiCl_4$, PH_3, CsCl, H_2S, H_2Se. (1, 240-245)

39. By means of suitable diagrams, represent the complete structure of $CaCl_2$, and CH_4. (All references under number 37)

40. Show the electron arrangement of the following compounds: $AlCl_3$, NH_4F, NO, MgO, H_2O. (All references under number 37)

41. In what two ways may certain elements exhibit variable valence?

42. What is meant by radioactivity? State briefly the contribution to the study of radioactivity by Antoinne Becquerel,

Pierre and Marie Curie and Ernest Rutherford. (1, 220-221; 2, 43-45; 7, 253-254)

43. What is the nature of each of the three kinds of radiations emitted by the radioactive elements? List each emission under the vertical headings: name, symbol, composition, and penetrating effect. Which is a light ray, and which are particles? What evidence proves your choice? (2, 49; 4, 224-228)

44. What happens to an atom which undergoes radioactive disintegration? (4, 234)

45. How does the emission of a Beta-particle change the atomic number and atomic weight of an atom? How does the emission of an Alpha-particle change the atomic number and atomic weight of an atom? (8, 300)

46. What is the effect of heat, light, pressure, and water on the rate of decomposition of radioactive elements? (8, 296)

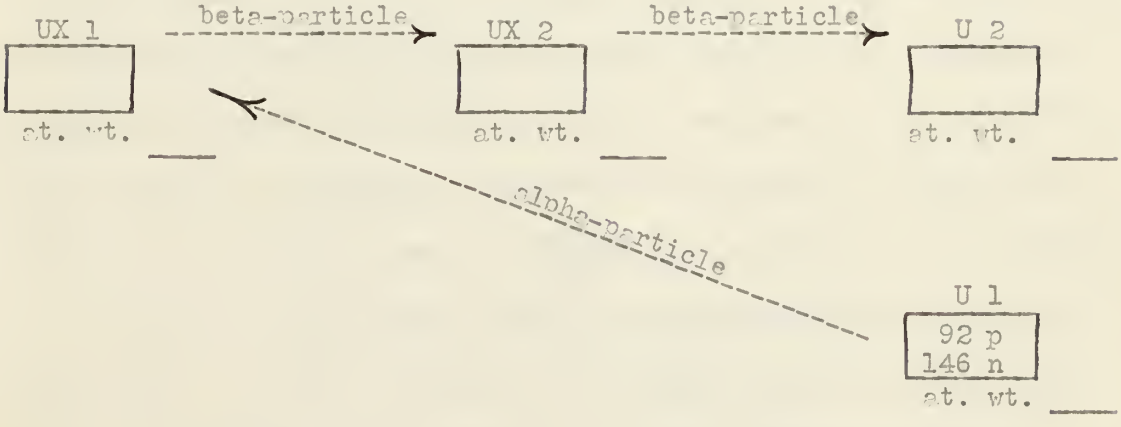
47. What is meant by the half-life of radio active elements? (4, 231; 8, 302-303)

48. How are non-radioactive elements disintegrated? What are the products of disintegration? Give examples. (4, 254-256; 5, 194-198; 8, 306-310)

49. Thorium(atomic number 90, atomic weight 232), like uranium, is the head member of a radioactive series. Thorium loses an alpha-particle to form mesothorium 1 (MsTh 1) which in turn loses a Bete-particle to form mesothorium 2 (MsTh 2). What are the atomic weights of MsTh 1, and MsTh 2? What are the atomic number of MsTh 1,

and MsTh 2? Which of these products are isotopes?

50. In the following table are given the products of disintegration of uranium and the character of the change by which each is formed. Calculate the nuclear composition of each disintegration product in terms of protons and neutrons. What is the atomic weight of each product? Which of these products are isotopes?



Optional Related Activities

1. Make a visit to the Harvard Chemical Museum or the chemistry building at M. I. T.. What apparatus do you find which shows the experimental work of the great men in the field of atomic structure? Explain how each piece of apparatus works. How many of the famous men involved in these experiments are still alive?

2. Make a diagramatic drawing of the atoms in the eighth group. Show the composition of the nucleus in terms of the number of protons, neutrons, and the resulting atomic weight. The diagrams should also show the number of electrons in each of the planetary levels.

The following chart is another way of expressing the number of electrons in each planetary level.

INERT GAS	LEVEL K	LEVEL L	LEVEL M	LEVEL N	LEVEL O	LEVEL P	LEVEL Q

7. Select any atom and show how it has been characterized in the past (Dalton's Atomic Theory); and how the conception has changed to present day theories. The particular atom selected can be represented by a series of drawings or diagrams with appropriate explanations such as, date of theory, name of theory, and originator of the theory.

4. Select an atom with a very low atomic number and model it in clay or wood. Careful attention must be given to the relative size of the particles involved as well as to their relative positions. Although the electrons are in reality not attached to the nucleus, a physical attachment of the electrons to the nucleus may be necessary for all practical purposes; however, concentric glass balls may be used.

5. Show by means of diagramatic drawing what happens when the following atoms unite:

A. $Na + Cl$ ---- (Na^{+}, Cl^{-})

B. $2Al + 3O_2$ ---- $)2Al^{+++}, 3O_2^{=})$

C. $2H + O$ ---- H_2O

D. $C + 4Cl$ ---- CCl_4

The series showing each reaction should be drawn on 5 x 8 cards which can be used on the opaque projector.

6. Photograph in black and white or color various models of atoms or molecules that you may find in Museums, Universities and commercial supply houses. Photoflash pictures will give the best results, but, if the models can be exposed to direct sunlight, any camera can be used. Each photograph (about 3" x 4") should be mounted on regulation typing paper so that appropriate comments can be made. These comments should include:

A. Institution where photograph was made

B. When the photograph was made

C. Who made the model

D. When the model was made

E. What theory does it represent

7. Many forms of the periodic chart are in print. One of the most impressive forms is called M. Courtines' Castle. (3, 344-346) Make a similar model expanded to 1.5 feet x 4 feet. Be prepared to explain it to the class.

8. Select ten students at random or of a special group and ask each of them the same question taken from the list below?

A. How does atomic energy affect me?

B. What is the relationship of atomic energy to medicine?

C. What is the relationship of atomic energy to engineering.

D. What is the relationship of atomic energy to religion?

E. How does the liberal arts student view the atom?

F. What is the political significance of the atom bomb?

G. Of what concern is the atom bomb to the U. N. O.

Each of the questions can be incorporated in a form which is suggested on the back of the 5 x 8 card.

9. Make a collection of newspaper and magazine articles published within the last year which bear on the topics of this unit. The articles can either be physically attached to regulation type paper or copied on it. The individual sheets should also contain the following information:

A. Name of article

B. Name of author

C. Name of publications

D. Date of publication

E. Your reaction

The collection of articles should then be attached and contained in a folder.

10. If you have heard a formal lecture or an informal talk within the last year, on the topics of this unit, write a summary of the talk or lecture using the following list as a guide:

A. Name of student

B. Name of speaker

C. Date of lecture or talk

D. Place

E. Approximate number present

F. Subject of talk

G. Your comments

11. Write a paper on the following question: What was Dobereiner's contribution to the classification of the elements?

13. Write a paper on the following question: What was Newlands' contribution to the classification of the elements: Mention the time when he proposed his theory, the theory, and how he developed it. Charts will be very helpful in showing the development of his theory. Where did he present his theory? Was it generally accepted? What were the good points and what were the weaknesses of the theory?

14. Write a paper on the theme: Mendeleeff's contribution to the classification of the elements. The following may serve as a guide: Who was Mendeleeff? When did he propose his periodic law? Show by means of appropriate charts and diagrams how he developed his theory. Where and how did he present the theory? Was it well received? Was it universally accepted? Why? What predictions did he make? Was he successful? Why did he not predict the discovery of the inert gases? What are some defects of his periodic chart? (Moore, F. J., History of Chemistry)

15. List and make reproductions of every type of periodic chart that can be found in textbooks and other sources. Be sure to include the source of the chart and the author if possible.

16. Using the chart on p. 241 in reference text 11, (Fig. 71), describe every step of the transmutation in terms of composition of the nucleus and the atomic weight. Also, make a list of all isotopes.

16. What heavy isotope is used and what biological processes are revealed in the assimilation of fats and sugar in the body? What isotope is now used for studying proteins? Describe the process

if possible.

17. Literature from the Atomic Energy Commission has not arrived as yet. When it does, it will be incorporated in this section.

FINAL TEST
UNIT - THE ATOM

Answer Sheet

Name_____Section_____Date_____

Part 1 - Multiple Choice

1 ( )	11 ( )	21 ( )	31 ( )
2 ( )	12 ( )	22 ( )	32 ( )
3 ( )	13 ( )	23 ( )	33 ( )
4 ( )	14 ( )	24 ( )	34 ( )
5 ( )	15 ( )	25 ( )	35 ( )
6 ( )	16 ( )	26 ( )	36 ( )
7 ( )	17 ( )	27 ( )	37 ( )
8 ( )	18 ( )	28 ( )	38 ( )
9 ( )	19 ( )	29 ( )	39 ( )
10 ( )	20 ( )	30 ( )	

Part II - True or False

40 ( )	49 ( )	58 ( )	67 ( )
41 ( )	50 ( )	59 ( )	68 ( )
42 ( )	51 ( )	60 ( )	69 ( )
43 ( )	52 ( )	61 ( )	70 ( )
44 ( )	53 ( )	62 ( )	71 ( )
45 ( )	54 ( )	63 ( )	72 ( )
46 ( )	55 ( )	64 ( )	73 ( )
47 ( )	56 ( )	65 ( )	74 ( )
48 ( )	57 ( )	66 ( )	75 ( )

FINAL TEST
Unit - The Atom

Part 1. Multiple choice:

Directions: Each item consists of a question or an incomplete statement that can be answered or completed by one of the five lettered choices given. For each item, place the capital letter of your choice in the parenthesis after the item number on the answer sheet.

Sample: 1. The helium atom has the following number of electrons:

(A) 1
(B) 2
(C) 3
(D) 4
(E) 5

Answer sheet: 1. (B)

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1. Which of the following has fewer positive charges in the nucleus than electrons outside the nucleus?
   (A) A neon atom
   (B) A sodium atom
   (C) A sodium ion
   (D) A chlorine Atom
   (E) A chloride ion

2. How does the magnesium atom compare with the magnesium ion?
   (A) Both have the same nuclear charge
   (B) Both have the same number of planetary electrons
   (C) The magnesium atom weighs two atomic weight units more than the Mg ion
   (D) The magnesium ion has more protons in the nucleus
   (E) The magnesium has less neutrons in the nucleus

3. Which of the following defines the term isotope?
   (A) Atoms having the same atomic weight but different atomic numbers.
   (B) Atoms having the same atomic number but different atomic weights.
   (C) Atoms in the same group of the periodic table but in different series.
   (D) Atoms with different chemical properties.
   (E) Atoms existing in two crystalline forms, as graphite and diamond.

4. Which of the following is not a product of natural radio-active disintegration?

(A) The alpha-particle
(B) The positron
(C) The electron
(D) The proton
(E) The neutron

5. Rutherfords experiments in bombarding god foil with Alpha-particles indicates that:
(A) The nucleus contains most of the mass of the atom.
(B) The positive charges in the atom are scattered.
(C) Matter is relatively dense and solid.
(D) Electrons and protons are intermingled.
(E) The nucleus is a large part of the total volume of the atom.

6. Which of the following is not a postulate of the Bohr Theory?
(A) Electrons can revolve only in fixed orbits about a nucleus.
(B) An atom may absorb energy and cause an electron to be lifted into a higher energy level.
(C) The electrons emit light as they fall from a higher energy level to a lower energy level.
(D) The maximum number of electrons that the M shell of energy level can hold is eighteen.
(E) All energy levels are circular orbits in which one or more electrons may circulate.

7. Ions of elements:
(A) Contain only electrons and protons
(B) Are always charged positively
(C) Are electrically neutral
(D) Are produced when an atom gains or loses protons
(E) Are produced when an atom gains or loses electrons.

8. The atomic number of calcium is 20, the atomic weight is 40. The difference is due to:
(A) Weight of electrons
(B) Existence of isotopes
(C) Neutrons in the nucleus
(D) Allotropic forms of calcium
(E) Alpha-particles in the nucleus

9. The chemical activity of an element depends upon the number of electrons in the following level:
(A) K level
(B) All the levels
(C) Outer-most level
(D) Next to the outer-most level
(E) None of the levels

10. Elements whose outer ring of electrons is complete are chemically:
(A) Positive
(B) Negative
(C) Unstable
(D) Inactive
(E) Transitional

11. An element of atomic number 35 has the following electrons in the outer planetary ring:
(A) 2
(B) 3
(C) 4
(D) 7
(E) 8

12. The molecular weight of "heavy water" (D_2O) is:
(A) 16
(B) 17
(C) 18
(D) 19
(E) 20

13. The sodium atom and the sodium ion contain the same number of:
(A) protons
(B) electrons
(C) planetary rings
(D) protons and electrons
(E) beta-particles

14. Isotopes are a function of:
(A) electrons
(B) protons
(C) neutrons
(D) alpha-particles
(E) positrons

15. A good deal of our information concerning the structure of the atom has come from the use of the:
(A) Microscope
(B) Spectroscope
(C) Telescope
(D) Atomscope
(E) None of these

16. One argument that proves that the alpha-particle is not the smallest positively charged particle is the existence of:
(A) Hydrogen ions
(B) Isotopes
(C) Neutrons
(D) Electrons
(E) beta-particles

17. The term electron corresponds to:
(A) The ultimate part of a substance that retains the chemical properties of that substance.
(B) An atom or group of atoms having an electrical charge
(C) The most rapidly moving particle
(D) The unit particle of an element
(E) The smallest particle in an atom

18. For some of the lighter elements, the atomic weight is almost twice the atomic number. The number of electrons in the outer orbits of these atoms should be equal to:
(A) The total number of protons in the nucleus
(B) The number of electrons in the nucleus
(C) Half the number of isobars of that element
(D) Twice the number of excess protons in the nucleus.
(E) The total number of protons and neutrons in the nucleus

Use the accompanying table in answering questions 19-26. The fictitious elements with the symbols P, Q, R, S, T, U, V, W, X, Y, Z are located in the periodic system as follows:

Group	O	I	II	III	IV	V	VI	VII
2nd Series.....	U	X	Y	Z	P.....		Q	R
3rd Series.....	V	W	.....				S	T

19. Judging from its position in the periodic table, what type of element is element W.
(A) A metal
(B) A non-metal
(C) An inert gas
(D) Unmore ictible in character
(E) Amphoteric

20. Which of the following is the best reducing agent?
(A) V
(B) X
(C) U
(D) Y
(E) T

21. Which of the following is the most metallic element?
(A) W
(B) V
(C) P
(D) S
(E) Z

22. What is the most probable formula of the compound Y and Q?
(A) YQ
(B) YQ_3
(C) Y_2Q
(D) Y_3Q
(E) YQ_2

23. Which of the following is most likely to be formed by electron transfer, (electrovalence)? A compound of:
(A) U and R
(B) P and R
(C) Z and P
(D) Y and T
(E) Q and T

24. What type of ions would you expect element V to form in solution?
(A) Only positive ions
(B) Only negative ions
(C) Both positive and negative ions
(D) No ions
(E) Complex ions

25. One of the following is the most active electron acceptor:
(A) P
(B) Q
(C) R
(D) S
(E) T

26. The following is a correct formula: (Oxygen and Hydrogen are represented by their own symbols)
(A) XO_2
(B) YC
(C) UO_3
(D) QH_3
(E) RH_4

---

27. Dobereiner's classification was based on:
(A) Atomic weights
(B) Colors of elements
(C) Divisibility of the mass of the elements by three
(D) The metals
(E) Properties of the elements

28. Newlands arranged the elements:
(A) According to increasing alphabetical order in groups of eight
(B) Most accurately in the region of heavy atomic weights
(C) More accurately than Mendeleeff
(D) According to increasing atomic weights in groups of seven
(E) According to increasing atomic weights in groups of eight

29. The most serious weakness in Newlands' Law of Octaves was that:
(A) It misplaced the noble gases
(B) It could not be extended accurately beyond the first twenty elements
(C) There was no place for Hydrogen
(D) It interchanged the places of Co and Ni, I and Te, K and A
(E) It did not take into consideration the inert gases

30. Meldeleeff's statement of the periodic law as that the properties of the elements are periodic functions of:
(A) The number eight
(B) Their atomic weights
(C) Their atomic numbers
(D) Their physical constants
(E) Their groups

31. Elements that form amphoteric compounds are in the periodic table approximating the:
(A) Right
(B) Center
(C) Left
(D) Bottom
(E) Top

32. The maximum valence of an element toward Hydrogen is:
(A) 1
(B) 2
(C) 4
(D) 6
(E) 8

33. The maximum valence of any element toward Oxygen is:
(A) 2
(B) 4
(C) 5
(D) 6
(E) 7

34. The periodic system is valuable because it:
(A) Stresses variable valence
(B) Classifies the rare elements and their properties
(C) Gives a good classification for Hydrogen
(D) Goes beyond Uranium
(E) Systematizes our knowledge of the elements

35. The position of the most metallic element on the chart is:
(A) Upper left-hand corner
(B) Lower right-hand corner
(C) Upper right-hand corner
(D) Lower left-hand corner
(E) In the middle

36. The position of the least non-metallic elements on the chart is:
(A) Upper left-hand corner
(B) Lower right-hand corner
(C) Upper right-hand corner
(D) Lower left-hand corner
(E) In the middle

37. The maximum number of electrons in the outer orbit of any group (excluding the inert gases) is equal to:
(A) The maximum valence of an element in that group with respect to Hydrogen
(B) The maximum valence of an element in that group with respect to Oxygen
(C) The difference between eight and the value in (a)
(D) The difference between eight and the value in (b)
(E) The difference between the value in (a) and the value in (b)

38. The oxygen family is indicated on the chart by:
(A) Group five; sub-group B
(B) Group six; sub-group B
(C) Group five; sub-group A
(D) Group six; sub-group A
(E) Group four; sub-group B

39. Elements located on the diagonal line on the periodic chart are termed:
(A) Amphoteric
(B) Transitional
(C) Inert
(D) Agonic
(E) None of these

Part 2 - True or False

Directions: The following statements are eith true or false. If the statement is true, place a plus (+) sign in the parenthesis after the item number on the answer sheet; if the statement if false, place a minus (-) sign in the parenthesis.

Sample: 1. Electrons are positively charged.
2. Electrons are negatively charged.

Answer sheet: 1. (-)
2. (+)

---

40. Electrons are larger than protons.

41. The number of electrons in an atom depends on the atomic number.

42. The alpha-particle is an ion of Helium.

43. The loss of an alpha-particle brings about a gain on one unit in atomic number.

44. The loss of a beta-particle does not entail a change in atomic weight.

45. No element can exhibit a valence greater than eight.

46. The name series is applied to the elements in the vertical columns of the periodic chart.

47. The "L" energy level never holds more than eight electrons.

48. The "N" energy level can hold as many as 32 electrons.

49. The proton has the same charge as the positron.

50. An element of atomic number 17 has an electrovalence of plus 1.

51. Electrons have a mass equal to that of a proton.

52. Electrons are particles produced during natural radioactivity.

53. Positrons are products of natural radioactivity.

54. The first electron set is considered complete when it contains eight electrons.

55. Heavy Hydrogen (Tritium) contains one neutron.

56. The cyclotron is an instrument for producing natural radioactivity.

57. Mendeleeff's predictions were a basis for universal adoption of his periodic chart.

58. The alpha-particle contains two electrons and two neutrons.

59. The beta-particle is actually a light ray.

60. Gamma rays cannot be bent by a magnetic force.

61. The molecular weight of heavy water (D-O-T) is 20.

62. Graphite is an allotropic form of carbon.

63. Antoine Beccuerel discovered radium.

64. The beta-particle is a charged particle.

65. The gamma-ray has a greater penetrating quality than the alpha-particle.

66. The alpha-particle has a greater penetrating quality than the beta-particle.

67. The gamma-rays do not effect a photographic plate.

68. An atom of atomic number 20 and atomic weight 40 is an isotope of another atom of atomic number 20 and atomic weight 41.

69. Artificial radioactivity is produced by bombarding a target with heavy hydrogen bullets..

70. X-rays are produced when an atom is bombarded with electrons.

71. The discovery of x-rays has confirmed Mendeleeff's Periodic Law.

72. Isotopes are separated photographically by an instrument called a Mass Spectrograph.

73. Isotopes have the same chemical properties because they have the same number of protons in the nucleus.

74. Electrovalent compounds are held together by single, double, and triple bonds.

75. Prout's Hypothesis states that all atoms should have even multiple weights of the atomic weight of hydrogen.

CHAPTER IV

Suggestions to Teachers for the Use of the Two Source Units

Use as a source of information.-- As the name implies, these units may serve as a source of information and a guide for the organizing and planning of new units on the stated and allied topics. They can serve as a reference to specific objectives and activities for both teachers and pupils.

Use in their entirety.-- These units were constructed for classes on the college level and can be used in their entirety for classes composed of chemical engineering, chemistry major, and science major students if the instructor makes a grouping of topics similar to the topics included in either or both of the units of this paper and if the objectives of the instruction coincide with the itemized statement or delimitation of these units.

Use as nucleus for construction of other units.-- If one or a few of the total number of topics of the source units is to be considered in the construction of a unit, portions of the source units may serve as a nucleus or nuclei for the development or expansion to a full unit or can supplement what has already been considered.

Use as optional related activities.-- Portions of the study guides which do not have a place in the construction of new units or units already in existence, can effectively be used as optional related activities.

Use in high school chemistry courses.-- High school instructors can use much of the material of the unit on Some Fundamentals Of Chemistry because of the extensive rather than the intensive coverage of the topics included. The extensive coverage will bring the degree of subject difficulty into the realm of the high school student.

Use of pertinent parts for other type chemistry and related courses.-- Pertinent parts of the two source units can be extracted for use in a course for liberal arts students, students who do not need a thorough background in chemistry, or students who are taking a course in general science on the college level.

Use as a sample of unit organization.-- These source units may serve to acquaint teachers with the unit method of teaching by providing the format of organization and a sequence of activities necessary to the method.

A thought for the future.-- It is the hope of the writer that this paper will lead to the construction of better source units and consequently better teaching units.

Date Due

AUG 29 1951	NOV 23 1957
AUG 7 1951	
OCT 22 1951	DEC 2 1957
DEC 8 1951	In use
JAN 16 1952	JUN 30 1958
APR 26 1952	In use
JUL 31 1952	
AUG 12 1952	Room use
JAN 8 1953	
JAN 15 1953	
MAY 12 1954	
DEC 3 1955	
DEC 10 1956	
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